MULTIMEDIA UNIVERSITY®

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2022/2023 (TERM ID 2210 & TERM ID 2215)

EME1026 – FLUID MECHANICS

(ME)

15 FEBRUARY 2023
2:30 p.m. – 4:30 p.m.
(2 hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of FIVE pages including cover page.
2. There are FOUR questions in total.
3. Attempt **ALL** questions. All questions carry equal marks.
4. Please write all your answers in the Answer Booklet provided.

Question 1

An inclined 2-*m* wide, 1.2-*m* long rectangular gate ABCD weighing 1500 *N*, is hinged along its top edge BC as shown in **Figure Q1**.

(a) Sketch a pressure distribution on the plate with necessary labelling and determine the magnitude of the hydrostatic force acting on the gate. **[9 marks]**

(b) Find the location of the force in part (a). Indicate the location on a suitable sketch. **[9 marks]**

(c) The gate is held in equilibrium by a force R, acting perpendicularly to AD. Sketch the free body diagram of the plate with necessary labelling and determine the magnitude of R. **[7 marks]**

Take density of water as 1000 kg/m^3.

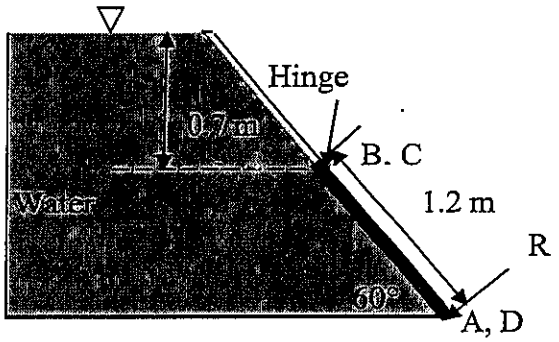
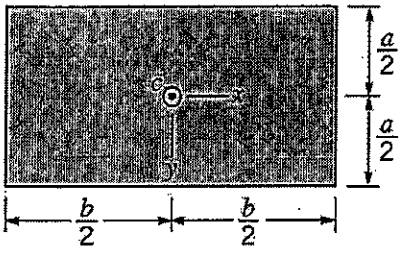


Figure Q1

Note: You may need the geometric properties of a rectangle



$A = ba$

$I_{xc} = \frac{1}{12}ba^3$

$I_{yc} = \frac{1}{12}ab^3$

$I_{xyc} = 0$

Continued.....

Question 2

(a) Water flows through a *horizontal* bend and discharges into the *atmosphere* as shown in **Figure Q2a**. The water volume flow rate is 0.03 m^3/s and the x direction anchoring force required to hold the bend, $F_x = -300$ N; the *minus* sign indicates the force points in the direction *opposite* to the x axis. The flow cross sections at the inlet and outlet of the bend are as shown in **Figure Q2a.**

By sketching a suitable *control volume* with all the necessary details labelled, determine:

(i) the pressure at section (1), and **[13 marks]**

(ii) the y direction anchoring force required to hold the bend in place. **[6 marks]**

Take density of water as 1000 kg/m^3.

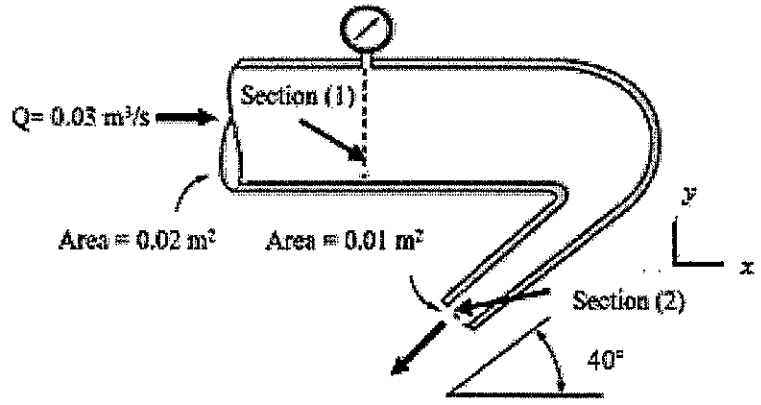


Figure Q2a

(b) A steady air flow through a converging nozzle of length, L= 0.15 m can be approximated by the velocity distribution, u as a function of x, where x is the axial distance from the entrance, and V_o = 0.25 m/s.

$$u = V_o\left(1+\frac{2x}{L}\right)$$

Take density of air as 1.23 kg/m^3.
Determine:
(i) the fluid acceleration at the exit of the nozzle, and **[3 marks]**

(ii) the pressure gradient at the exit of the nozzle. Viscous effects are negligible. **[3 marks]**

Continued...

Question 3

(a) A sphere of diameter D is placed in a fluid with density ρ, kinematic viscosity ν, and moving with fluid velocity V. Use dimensional analysis to show that the relation of the drag force on the sphere to the flow parameters is

$$F = \rho V^2 D^2 \Phi\left(\frac{VD}{\nu}\right).$$

[12 marks]

(b) A sphere of diameter D_w when placed in water moving with a velocity of 1.5 *m/s* experiences a drag force F_w of 4.5 *N*. Another sphere of diameter D_a, where $D_a = 2D_w$, is placed in a wind tunnel. The kinematic viscosity of air as 13 times that of water, and the density of air is 1.28 kg/m^3. The density of water is 1000 kg/m^3.

(i) Find the velocity of air in the wind tunnel for dynamic similarity with the sphere in water.

[6 marks]

(ii) What is the drag force in the wind tunnel with air at the speed of (i)?

[7 marks]

Continued...

Question 4

A turbomachine has inner impeller diameter of 1000 *mm* and outer diameter 2000 *mm*, with a uniform width of flow cross-section being 120 *mm*. Water enters radially at the inner impeller and exit at the outer impeller which has a blade angle of 62°. The flow rate through the machine is 4 m^3/s while the rotation speed is 350 rpm. Take water density as 1000 kg/m^3 and assume ideal flow conditions with no losses, and the absolute velocity of the inlet water is directed radially.

(a) Draw the velocity diagrammes at the inlet and outlet of an impeller, labelling the velocity components. **[6 marks]**

(b) What is the blade speed at the inlet? **[2 marks]**

(c) What is the absolute speed of the water at the inlet? **[2 marks]**

(d) What is the blade angle at the inlet? **[3 marks]**

(e) Find the absolute velocity of water at the outlet. **[6 marks]**

(f) Justify whether the machine is a pump or turbine by calculating the torques acting on the blade. **[6 marks]**

End of paper